Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

SOME CONSIDERATIONS IN ESTIMATING THE SANITARY QUALITY OF WATER SUPPLIES

By W. H. Frost[1]

The subject indicated by the title of this paper is obviously too broad to be comprehensively discussed within a brief space. The present discussion will, therefore, be limited, first of all to a consideration of water supplies with reference solely to the causation of typhoid fever, which is the typical, and in this country the most common and serious water-borne infectious disease. The scope may still further be limited to a discussion of the general nature of the evidence upon which an opinion as to the sanitary quality of a water supply must be based.

A scientific basis for estimating the sanitary quality of a water supply with reference to its effect in the causation of typhoid fever can be established only by coördinating the results of two distinct lines of study. The first has to do with the nature and extent of the pollution of the water; the second with the extent of the effect produced by a given amount of pollution in the causation of typhoid fever.

The point which it is desired to especially emphasize is that knowledge of the pollution of a water supply has no significance except as it is coördinated with a knowledge of the effect which the known degree of pollution will produce. However precisely we may be able to determine the nature and extent of pollution, the accuracy of an estimate of the sanitary quality of water must always be limited by the precision with which its effects can be determined or estimated.

DETERMINATION OF THE EXTENT OF POLLUTION

The nature and extent of the pollution of a water supply is determined by studies from two angles, namely: first, by a survey of the sources of pollution, and of the safeguards which stand between these sources and the ultimate consumer of the water; second, by laboratory examinations designed to determine the actual amount and kind of pollution present.

---

[1] Past assistant surgeon, U. S. Public Health Service.

SANITARY SURVEY

Since typhoid fever is caused solely by the typhoid bacillus, a sanitary survey of the sources of pollution of a water supply should have reference primarily to the sources of pollution with typhoid bacilli. These organisms, so far as known, breed only in the bodies of infected persons, whence they are discharged in the feces and urine. The term "infected persons" comprises not only all persons known to be ill with typhoid fever, but also a considerable proportion of recent convalescents, and a small proportion, probably about 2 per cent, of all persons who have previously had typhoid fever; perhaps also a small proportion of persons who have never shown recognizable symptoms of infection. By a careful survey it is possible to enumerate all the visible sources of typhoid infection, that is all the known cases of typhoid fever from which a given water supply may become polluted. The concealed sources, that is convalescents and "carriers," cannot be individually located; but their probable numbers in a well studied population can be estimated with reasonable accuracy.

It may be considered that all water, whether taken from surface or underground sources, has at some time since its precipitation been in contact with the surface of the earth, and has consequently been more or less exposed to pollution with the intestinal discharges of all persons and lower animals upon its catchment area. Between the sources of pollution and the ultimate destination of the water are numerous agencies operating to reduce the numbers of typhoid bacilli and other intestinal bacteria which may reach the consumer. These safeguards comprise all the agencies which tend to destroy typhoid bacilli and other intestinal bacteria in the natural and artificial processes of sewage disposal and water purification. In order, then, to arrive at an estimate of the numbers of typhoid bacilli which will reach the consumers of a water supply from known sources of pollution, it would be necessary to calculate accurately the extent of the action of all these agencies which tend to diminish pollution. The problem is so complex as to be impossible of solution without the aid of further means of observation.

BACTERIOLOGICAL EXAMINATIONS

Of the laboratory examinations applicable to determining the nature and extent of pollution of a water supply bacteriological examinations have the most direct bearing upon sanitary quality, which is a question of bacterial pollution. The most specific of the bacteriological examinations in general use are quantitative tests for bacteria of the B. coli group, since these tests afford a direct measure of the numbers of intestinal bacteria present, and since typhoid bacilli are found only in association with intestinal discharges. Nevertheless, such tests, however accurate and specific they may be, show only the extent of pollution with intestinal discharges in general; they do not distinguish between pollution with intestinal discharges from lower animals which are not subject to infection with typhoid bacilli, and the much more dangerous pollution from human sources. They still further fail to distinguish between human discharges actually containing typhoid bacilli and discharges free from this specific infection.

CORRELATION OF SANITARY SURVEY AND BACTERIOLOGICAL EXAMINATIONS

The significance of bacteriological examinations may be greatly increased by correlation with a careful sanitary survey, which gives information as to the probable sources of such intestinal bacteria as may be present. It is conceivably possible, by combining a careful sanitary survey with bacteriological examinations, to estimate roughly the probable numbers of typhoid bacilli present in a given water supply. The data necessary for such an estimate are:

1. A knowledge of the numbers of intestinal bacteria present in the water.
2. Such knowledge of the sources of pollution as to enable an estimate of the proportion which intestinal bacteria from human sources are of all intestinal bacteria present.
3. An estimate of the ratio of typhoid bacilli to all bacteria of the B. coli group in the discharges of the human population which contributes to the pollution of the given water supply.

A more or less accurate estimate of the probable numbers of typhoid bacilli present in a water supply represents the maximum of information which we may hope to obtain regarding the nature and extent of the significant pollution. Even this complete knowledge, however, would fail to give an accurate measure of the sanitary quality of the water, unless it could be correlated with a knowledge of the effect which the known numbers of typhoid bacilli will produce in the causation of typhoid fever among persons who drink the water.

To recapitulate; sanitary surveys and bacteriological examinations give only indirect and inferential knowledge as to the probable presence and numbers of typhoid bacilli in a water supply. Even were this knowledge much more direct and exact, it would still fall short of being all that is needed for an estimate of the sanitary quality of the water. The second requisite is an equally exact knowledge of the effects which the known pollution will produce.

DETERMINATION OF THE EFFECTS PRODUCED BY WATER SUPPLIES IN THE CAUSATION OF TYPHOID FEVER

The exact dosage of typhoid bacilli necessary to cause infection is unknown, primarily because it has not been possible to determine directly the numbers of bacilli actually ingested by individuals who have contracted typhoid fever. Determination of the effects of a given dosage of typhoid bacilli even by indirect means is exceedingly difficult because of the probable influence of several variable factors other than dosage in causing infection.

Infection signifies more than the mere introduction into the human body of a given number of living specific organisms; it signifies the establishment of these micro-organisms within the body, their multiplication, invasion of the body tissues and the formation of toxic products, all of which must be accomplished against the resistance of the human body. The introduction of typhoid bacilli into the human digestive tract inaugurates a struggle between the infecting organisms on one side and the human body on the other. Infection results only when the typhoid bacilli have overcome the resistance of the body in the preliminary stages of this struggle, and have reached a stage of development within the body such as to call forth a final effort against them, exhibited in a general reaction which we recognize as the symptoms of typhoid fever.

The following are some of the theoretical considerations which may influence the outcome of the struggle and determine whether or not infection will result from the introduction of living typhoid bacilli into the human body. On the part of the bacillus there is the factor of "infectivity," or ability to establish itself and multiply within the body. There is also the factor of "pathogenicity" or "virulence," that is ability, after having become established in the body, to give rise to toxic products which will result in illness. It is at least probable that typhoid bacilli may vary widely and perhaps independently in these two respects. On the part of the human body a variable factor is the ability to resist infection, or its antithesis "susceptibility." There is good reason to believe that susceptibility to typhoid infection varies widely in different individuals, and perhaps in the same individual at different times. Except for the fact that resistance is greatly increased by prophylactic vaccination and by a prior attack of typhoid fever, little is known of the circumstances which affect susceptibility; and there are no means of directly measuring the resistance or susceptibility of an individual to this infection.

Other things being equal, we may well suppose that dosage, that is, the number of typhoid bacilli introduced, is the factor which determines whether or not infection will result. It is highly probable that the resistance of the human body against typhoid infection is relative, not absolute; that an individual capable of resisting the invasion of a given number of typhoid bacilli would not be able to resist invasion of say ten times that number. Or, to state it differently, the more numerous the typhoid bacilli introduced, the greater is the probability that some of them will succeed in passing the defenses of the body. In comparing individuals, however, we cannot assume that dosage is the determining factor in infection because of the possible influence of the variable unknown factor of individual susceptibility. If, however, we divide a population into sufficiently large groups, similar in respect to age-distribution and other general characteristics, we may assume that the average of susceptibility is the same in all groups. Given, then, a uniform infective agent, that is typhoid bacilli derived from the same source, we may assume that dosage now becomes the determining factor; and that the occurrence of typhoid fever in any group will be proportionate to the exposure of that group to infection.

Reversing the argument, it may be concluded that the dosage or exposure to infection has been greatest in that group exhibiting the highest proportion of cases. This principle of reasoning is commonly applied in undertaking to locate the source of typhoid infection. The reasoning is valid only when the population groups are sufficiently large and the number of cases occurring in each sufficient to be significant.

This review of the factors entering into infection is intended to illustrate the difficulties in the way of determining the effects of a given dosage of typhoid bacilli. Even were it possible to undertake human experiments, it is obvious that these would have to be performed on a most extensive scale, with large groups of people and with bacilli derived from many sources, subjected to many conditions. Especially would it be difficult, by such experiments, to arrive at a definite conclusion regarding the minimum dosage of typhoid bacilli which might occasionally result in infection. As a matter of fact, lacking experimental observations, we have only indirect means of determining the probable dosage of typhoid bacilli necessary for infection.

SOURCES OF KNOWLEDGE CONCERNING THE EFFECTS OF WATER SUPPLIES IN CAUSING TYPHOID FEVER

A knowledge of the actual effects of water supplies in the causation of typhoid fever is derived from studies of epidemic outbreaks and endemic prevalence. The endemic typhoid occurring in any community includes the sum total of cases resulting from the operation of all causes. While communities differ markedly in respect to their rates of endemic typhoid prevalence no community of considerable size in this country is altogether free from the disease. An epidemic, in the commonly accepted sense, can not be precisely defined, since the term is a relative one. Any outbreak of cases sufficiently numerous and sudden to stand out distinctly separated from the usual endemic typhoid in that community may be considered an epidemic. The proportion of cases to total population which may be considered to constitute an epidemic depends, then, to some extent, upon the usual rate of typhoid prevalence in the community.

A sharply defined epidemic of typhoid fever affords the best opportunity to determine definitely the effect of a water supply in the causation of this infection. This is so primarily because the very distinctness and sudden development of an epidemic argue the operation of a single, distinct and unusual cause, the spread of infection from a single source, since it is essentially improbable that two or more unusual sources of infection should have developed independently and simultaneously.

Space does not permit more than the briefest discussion of the methods whereby a water supply may be proven to have caused an epidemic of typhoid fever. Starting with a general knowledge of the sources and potential routes of typhoid infection, and with the assumption that the epidemic has had its origin from a single source, it remains to find the source and vehicle of infection common to all or most of the cases. This is accomplished by investigation of each case, inquiring into all the routes by which infection might have reached this case, that is into the circumstances of any exposure to infection from a recognized prior case of typhoid, and into the sources of all articles of food and drink. Comparing the histories of a sufficient number of cases it is easy to arrive, by elimination, at the vehicle of potential infection common to all, or nearly all. In the case of a water supply used by a large majority of the population the mere fact that all the typhoid patients have drunk this water is obviously of no special significance, since this would necessarily be so, no matter what the cause of the epidemic.

It is, in such case, necessary to *exclude other vehicles of infection*, to show that the water supply is the *only* vehicle of infection common to a significant proportion of the cases. The next step in the evidence is to demonstrate the probability that the water supply was infected with typhoid bacilli at such a time as to account for the epidemic. This can usually be accomplished, even though it may not be possible to find the individual sources from which the water supply became infected. Finally, if it is true that the water supply has been the means of disseminating the epidemic, all the circumstances of the outbreak will be more fully consistent with this than with any other hypothesis, forming a conclusive chain of circumstantial evidence.

A great number of well studied typhoid epidemics, conclusively traced to infection of water supplies, have afforded opportunities to observe and measure definitely the extent of infections caused by these water supplies among their consumers. Unfortunately, the water supplies responsible for such definite epidemics have seldom been closely examined bacteriologically during the period of their known infectivity, so that the extent of pollution which has produced the definitely determined effect is not known. The study of epidemics has, therefore, failed to give a definite idea of the probable dosage of typhoid bacilli responsible for the causation of known percentages of infection among those exposed.

The effect of water supplies in the causation of endemic typhoid fever is a matter of greater public health importance and at the same time more difficult to determine, because the endemic typhoid in a community represents the sum total of infections from all sources and through all routes. Our most definite knowledge and nearest measure of the effects of known water supplies in contributing to the endemic prevalence of typhoid fever is derived from the study of communities in which a distinctly marked change in the extent of pollution of the water supply has been followed by a correspondingly definite change in the rate of typhoid prevalence. Among the best examples are the many cities in which effective filtration of polluted surface water supplies, previously used without purification, has been followed by a marked decrease in typhoid prevalence. Even here, however, the observed reduction in typhoid prevalence is not an altogether reliable measure of the previous effect of the polluted water supply in the causation of this disease. It is possible, on the one hand, that a reduction in the amount of water-borne typhoid, eliminating a number of local sources of infection, may have resulted in a reduction of cases previously caused by secondary infection from these sources, thus magnifying the apparent effect of the water supply. On the other hand, it may be that the water-borne typhoid, though obviously reduced, has not been completely eliminated. The effect of this would be to reduce the apparent previous effect of the water supply.

A study of such communities as above cited, during the period when known polluted water was used, has revealed certain fairly distinctive characteristics in the distribution of typhoid fever in communities where a large proportion of the total endemic typhoid is water-borne. Briefly these characteristics are:

1. A rate of prevalence notably higher than in other communities, similar in respect to climate and other significant conditions, but using water supplies less highly polluted.
2. A prevalence relatively high during the winter and spring, often reaching its maximum in these months.
3. A relatively uniform distribution throughout the population, without reference to environmental factors other than water supply.

In these same communities, subsequent to purification of their water supplies, and in other communities where intensive studies have shown that the water supplies are small or negligible factors in the causation of the disease, endemic typhoid shows contrasting characteristics in its distribution, viz:

1. A rate of prevalence generally proportionate to the opportunities afforded for contamination of food supplies with human excrement. Conspicuous factors are faulty methods of local sewage disposal, resulting in the exposure of human discharges to flies and other carriers; and laxity of sanitary administration in respect to isolation of typhoid patients and the safeguarding of milk and other food supplies.
2. A seasonal prevalence quite regularly reaching its maximum during the summer and autumn months, declining markedly during the winter and spring.
3. A relatively high prevalence among those elements of the population who, by reason of their habits or environment, are evidently more exposed to infection from local sources.

These and other more or less distinctive characteristics in the distribution of typhoid fever assist materially in arriving at an estimate of the probable effect of the public water supply in contributing to the endemic prevalence of the disease in a given community. The accuracy of such an estimate is proportionate to the thoroughness and precision of the study upon which it is based. It may be emphasized, however, that the number and complexity of factors entering into the causation of endemic typhoid is such that we can not hope to estimate with quantitative precision the effect of water or any other single factor. An illustration will perhaps serve better than a general discussion to present a conception of the limitations of epidemiologic methods in determining the precise influence of a single factor.

Assume the hypothetical case of a city where a rather highly polluted surface water supply has been in general use, and where the average rate of typhoid incidence is 1000 cases per 100,000 of population yearly. Suppose that, in actual fact, 80 per cent of the total cases are due to infection conveyed by the water supply, the remaining 20 per cent being due to infection from all other sources. The distribution of typhoid in this community would, in all probability, be such as is characteristic of comunities in which a polluted surface water supply is the predominant vehicle of infection. By careful study, it should be readily possible to conclude that most of the typhoid was water-borne, and a relatively small proportion due to infection from other sources. It would not, however, be possible to determine definitely the exact percentage due to water and to other factors respectively. Suppose now that following the installation of filters, providing a water supply showing only slight evidences of pollution, the total incidence of typhoid fever in this community has been reduced to one-fourth, that is 250 cases per 100,000 yearly. Assume that factors other than water cause precisely the same amount of typhoid as previously, that is, 200 cases per 100,000, and that the water supply continues to cause the remainder, or 50 cases per 100,000. The proportion between the water supply and other factors in the causation of the disease has now been reversed, so that the water supply causes only 20 per cent of the total cases. Careful study might now be expected to show conclusively that by far the greater proportion of the cases were due to infection contracted from sources other than water supply. It is, however, extremely doubtful that it would be possible to determine conclusively whether or not the water supply continued to cause a certain small, not definitely determined proportion of cases. In other words, the methods of study are not sufficiently accurate to differentiate between, say, 20 per cent of cases due to water-borne infection, 10 per cent, and none.

The principle which the above illustration is intended to illustrate is simple. A number of factors, more or less obscure, complex and interrelated, enter into the causation of endemic typhoid fever. The operations of individual factors can be distinguished only by circumstantial evidence. Quite evidently the ease and certainty with which the effect of water supply or any other individual factor can be recognized is proportionate to the prominence of the factor. The larger the ratio of its effect to the combined effect of all other factors, the more distinctly can it be discerned. Conversely, as the effect of any single factor becomes smaller in proportion to the total, the greater the difficulty of recognizing and distinguishing it; and there is entirely good reason to believe that the effect becomes indistinguishable before the factor is entirely eliminated. Applying this principle to the judgment of water supplies, the fact that it is impossible to clearly detect evidence of water-borne infection in a community does not satisfactorily prove that the water supply actually plays no part in the causation of this disease. It must then be recognized that we are as yet unable to determine the least amount of pollution of a water supply which may be responsible for a very slight incidence of typhoid fever.

To recapitulate: bacteriological examinations, combined with a careful survey of the sources of pollution and of the safeguards against them, give accurate knowledge of the extent of pollution of a water supply in terms of intestinal bacteria from all sources. They give only indirect and inferential knowledge of specifically dangerous pollution with typhoid bacilli. To make the knowledge acquired by bacteriological examinations and sanitary surveys significant with respect to the sanitary quality of water, it is necessary to know the *effects* produced by a given amount of pollution. Such effects can be definitely ascertained and measured in the case of epidemic outbreaks, proven to be due to the use of polluted water supplies. The effects can be definitely recognized but not accurately measured in the case of highly polluted water supplies causing high rates of endemic typhoid prevalence. In the case of slightly polluted water supplies it is not philosophically possible to probe by present methods whether or not they may cause a relatively small incidence of typhoid fever, so small as to be obscured by other more prominent factors.

This paper is not intended to present a pessimistic point of view or to deny the possibility of forming a reasonably accurate estimate of the sanitary quality of a water supply. On the contrary, the writer wishes to express his entire confidence in the reliability of an expert opinion, formed after careful study from all angles, and stated conservatively, with an understanding of the limitations of the evidence. Unless these limitations are remembered, however, there is always the danger of drawing too sweeping conclusions from evidence bearing solely upon the extent of pollution of a water supply.

As regards establishing a firmer basis for opinions in the future, this must obviously be accomplished by improving and extending not only laboratory studies of the quality of water supplies, but equally epidemiologic studies of their relation to typhoid prevalence. Methods of epidemiologic study, like bacteriological and chemical methods must be so standardized that results can be summarized into a general fund of knowledge. Routine bacteriological examinations of water supplies, closely coördinated with careful, long-continued epidemiologic studies may be confidently expected to increase, perhaps to an extent not now foreseen, our ultimate knowledge of the sanitary safety of water supplies.

DISCUSSION.

Mr. Frederick H. Stover: Dr. Frost made the statement that improved water supplies in many cases got credit for doing more than they really did, in that, while they perhaps reduced the primal causes, and while many secondary contact cases which might have resulted from these did not occur, the water supply erroneously got credit for the whole. Was the statement understood correctly?

Dr. W. H. Frost: No; the statement was not quite in that form. The statement was that it was a possibility.

Mr. Frederick H. Stover: In that case why should not the water supply have the credit? The decrease in typhoid mentioned above is due to the improved supply, therefore why does not the supply have the credit for accomplishing it?

Dr. W. H. Frost: It does get the credit, but there is a possibility of an error.

Mr. William H. Jewell: The speaker was very much interested in Dr. Frost's paper, because there are a lot of mighty fine facts stated there—a lot of material to think about and work upon; but the thought was suggested that a matter concerning the vital statistics of typhoid fever in our municipalities was one that was correlated with the milk supply, and the question arose whether we ought not to consider the effects of the water that goes into the milk, either directly or indirectly, in relation to the typhoid statistics of our cities.

An instance occurred at the little village of Park Ridge, near Chicago, where they had twenty cases of typhoid fever, one right after another, in less than ten days, and the public schools had practically to close. Now that was traced by the health commissioner to a certain milk supply. After looking into the question a little bit, it was found that this dairyman was supplied with water from the owner's well. Now, he was within the corporate limits and the supply of the village water works was available. It would seem that it is not doing the water works manager or superintendent justice not to consider those cases, and if possible provide some means to make these dairies take city water when they are within the limits of main extensions, and the speaker thinks that you will find that where the milk supply of a local community is derived largely from its environments, and water mains are extended out the typhoid becomes less, due to the general propaganda against impure well water.

Dr. Bartow was asked if he knew of any jurisdiction over the water supply of these dairies in the state; and it appears that, in Illinois, there is no investigation being made of the water supplies for dairies, but there should be.

Dr. Jesse M. Worthen: At Charleston, S. C., last spring we had a hundred and sixty cases of typhoid within three weeks, and it was traced to the milk supply from two dairies, one using cistern water and the other using their own well water. One was within the corporate limits; the other was not, both of them were within three hundred feet of the water supply. The health officer traced the epidemic to these two dairies absolutely; and when they were made to sterilize everything, there were no new cases.

Dr. Edward Bartow: Those who have read the report on standards for interstate carriers have noticed that no chemical standards have been formulated, and they will notice that in the work which we did in the examination of our one hundred samples, we made chemical examinations. Apparently the chemical content of the water was pretty good.

Mr. Charles P. Hoover: It does not seem advisable, to the speaker, to establish a standard of hardness for water to be used by interstate carriers, but it might be well to insist that water containing more than one grain per gallon excess lime or any excess soda ash should not be used. This would prevent water tanks from being filled with water from railroad water softening plants. The speaker knows from experience that the water at these plants is sometimes grossly overtreated with the softening reagents. Again if the standard demanded a water of low degree hardness it would be a further incentive to use water from these plants. Although we have not, as yet, had time to give the new bacterial standard a thorough test, still we feel that it may be too high.

The daily bacterial records at the Columbus plant indicate that positive presumptive tests in 10 cc. portions of the filtered supply do not always mean an unsafe water, for they sometimes occur when 1 cc. portions of the same sample do not contain any bacteria. Therefore, the bacteriological standard for water adopted by the Treasury Department for the drinking water supplied to the public by common carriers in interstate commerce may work an injustice upon well regulated municipal water purification plants, for undue suspicion is apt to be thrown upon the plant, and the minds of the citizens may become unduly prejudiced against their public water supply if it becomes known that the water has at some time failed to meet the government requirements.

Mr. George R. Taylor: Will Professor Bartow please state whether in his opinion there would be any difference between the storage of a filtered water and the storage of an ordinary spring or raw water in the cooler. That is, will not the filtered water deteriorate more rapidly than water that has not been treated?

Dr. Edward Bartow: That would depend upon conditions. With the same kind of bacteria in each sample, the deterioration, which would be measured in the growth of bacteria, would probably be the same. With different bacteria to start with, measuring simply the number of bacteria, there would probably be a difference; but which would deteriorate the more rapidly the speaker would not pretend to say.

Dr. Jesse M. Worthen: Is the question of whether the ice used in the tanks on the common carriers is artificial or natural ever considered in the quality of the water after it has been iced?

Dr. Edward Bartow: Many of the common carriers, especially on the Pullman trains, do not allow the ice to come in contact with the water. In the coaches it is not quite so true. Natural ice is, as a rule, good when taken. It may be, of course, contaminated in handling. That is something that must be looked out for, and the railroads are coöperating to eliminate, as far as possible, any contamination after the water is collected.

Dr. Jesse M. Worthen: How about the manufactured ice? You very often strike it containing sodium chloride from leaky pans, and sometimes that comes in contact with the water and establishes a chemical standard of different elements that would increase the chlorine and ammonia if it came in contact with the water.

Dr. Edward Bartow: In the samples of water which we analyzed we found some with very little chlorine and a residue of from thirty to fifty parts per million. That would mean that the water which we obtained from the coolers was practically melted ice. It would be possible for a railroad in a country where the residue is high, a complaint that is often made through the southwestern states, to so dilute the water with ice water as to have a pure soft water that will conform to any standard; thus would be avoided any of the physiological actions on the passengers that would be caused by a change from a comparatively soft water to a water with a high residue consisting perhaps of sodium sulphate and magnesium sulphate. In the one hundred waters that we analyzed there were only three that had a residue of over five hundred.

Mr. Frederick H. Stover: It would seem that where there is only a bacteriological standard, it might be possible for carriers to get around that easily, simply by filling a supply tank from any convenient source, chlorinating this tank and then filling the containers in the cars from this. In this way it would be comparatively easy to take water from almost any convenient source and yet have it pass inspection when drawn from the coolers in the cars.

While it might be possible to obtain a fairly safe water in this way, and one that would pass the bacteriological test in many cases, the continued use of such a water would be apt to prove undesirable, since the supervision of such a small installation would in a majority of cases be inferior to that of a larger municipal supply.

A chemical standard if adopted should be along broad lines and susceptible of a liberal interpretation.

Mr. Wilson F. Monfort: Will Mr. Hoover explain one matter in his discussion, when he spoke of gas formation; does he refer just to the formation of gas in lactous broth?

Mr. Charles P. Hoover: Gas formation in both lactose bile and dextrose broth. In some of the tabulated literature on bacterial work it has been noted, on several occasions, that more B.

coli were found than total numbers of bacteria. If these results are correct then it would appear that too much dependence cannot be placed on results obtained with liquid media.

Dr. W. H. Frost: The speaker has no special license to act as spokesman for the public health service, but he may, perhaps, be able to present a point of view from the side of the service. The public health service has not only the authority but the responsibility of protecting the health of passengers in interstate traffic. There are two ways in which the question of controlling the water supplies on common carriers may be approached. First, by instituting an inspection of all the sources of water supply and by maintaining careful supervision over them and over methods of handling, such as to insure that safe water will be served to passengers. This is, perhaps, the ideal way, but a little consideration will show that this method necessitates not only an extensive survey to cover all the sources of supply, but the maintenance of a large force to keep up supervision over these sources and the maintenance of another large force to supervise methods of handling the supplies.

The other angle from which the proposition might be approached is by applying the same principle as is applied in the enforcement of pure food laws; that is, by requiring that the water, as served to passengers, shall conform to certain specified standards of quality, placing upon the carriers the responsibility of choosing such sources of supply and methods of handling as will enable them to meet the requirements. This automatically imposes upon the carriers the necessity of using only good sources of supply and cleanly methods of handling.

The standards adopted by the Treasury Department are quite properly rigid and high, because of the fact which the speaker tried to bring out this morning, that it is difficult to say just where the danger line lies. It seems the only safe policy is to adopt such standards as will certainly insure safe water. Undoubtedly the regulations are rigid; but it is intended that they should be. Common carriers use only comparatively small amounts of drinking water, and, although it may involve using purification processes which would be quite expensive if applied on a large scale to municipal supplies, it is entirely practicable for carriers to purify their water supplies to the point where they meet the requirements.

The speaker does not know exactly what steps the public health service is taking or proposes to take in enforcing these requirements, or just how it is intended to apply the standards; but does know that the service does not wish to embarrass those of you who have charge of municipal supplies by wholesale condemnation of all water supplies which do not conform to these standards. If the application of these standards will help to encourage municipalities to improve their water supplies, that will be a good thing.

While speaking, in reference to a statement which Mr. Hoover made, that B. coli, according to standard methods of testing sometimes turn out ten times as numerous as the total bacteria, the speaker would say that he has never had any such experience; our results are very consistent. Of course it might easily happen that in a single examination or a small series the B. coli would figure out more numerous than total bacteria, but the speaker never found it so in the results of any considerable series.

Mr. Philip Burgess: Would not the embarrassment be rather upon the common carrier than upon the community? In an instance where a local Pullman sleeper starts in a city where no such certificate has been furnished and the Pullman Company is obliged to ship water at considerable expense into this city from a neighboring community which has a certificate. It seems that the embarrassment is upon the carrier rather than upon the community.

How are these certificates issued, for what period of time, and on what basis of examination?

Dr. W. H. Frost: At the present time it is merely a case of certifying water from certain sources. Certificates are issued after examinations made by state or local officials.

Mr. Philip Burgess: Not by any national officer?

Dr. W. H. Frost: No; the service calls upon state officers to make examinations of water supplies within their own states.

Mr. Wm. J. Orchard: In the New Jersey State Board of Health we had considerable opportunity to see the effect of the certificate issued to railroad companies in regard to the quality of water furnished in cars and stations. Whenever we received a request from any of the many railroads in New Jersey, for certification of a water supply, we not only examined the records of analyses on file in our laboratory, which we are required by law to make four times a year, but we also, wherever there was any question, had an inspection made of the water shed. The speaker was of the opinion, as other men of that department were, that this matter of certifying the water supply for common carriers would tend very much to improve the character of supplies in small towns where railroads use a considerable quantity of water for their coaches and cars.

Mr. George R. Taylor: In regard to certification in Pennsylvania, we have had considerable experience there as a private water company in making out these certificates. Many of the small towns which we supply have no local health authorities that know anything about the purity of the water, but many of these certificates have been turned over to us and signed by us, certifying that we make regular analyses of the water. In cities where we have local boards of health they have filled out these certificates, but our filling out of the certificates has been accepted by the railroad company, at least, as satisfactory. In our section no inspection has ever been made by the state health authorities.

Dr. D. P. Curry: The speaker wishes to ask two questions; they are not altogether related, but will ask both. One relates to submitting samples to the State Board of Health. Now, of course, the government has adopted an arbitrary standard, as they had to do, but the speaker cannot see the reason of the necessity of icing other samples sent to us, for in addition to that we are examining the water supply of the entire state—private wells, cisterns, streams, ponds, any source of water used or consumed by the family. Some portions of our state are seventy-two hours from the laboratory by the methods of transportation. Some are away back in the mountains. The constant complaint, when we send them a container, is "we cannot get ice." It costs too much money, and they say "will you allow us to send them in uniced by parcel post?" If it could be permitted, we could do a great deal more work. Being the only man in Kentucky excepting my assistants doing this work, it is impossible to cover the ground by personal inspection. Our analyst is not busy all the time. We want all the samples of water we can get, and we would like to ask the opinion of the men here who are familiar with the public health association whether it is possible that samples could be sent to us from a distance, uniced, by parcel post.

We get rather an increase than a decrease of bacteria. Of course, we know that the bacteria die as the result of storage, and it is a question whether, in the course of seventy-two hours, enough of these bacteria would die out to give us a sample which did not show the pollution. We do not object to the increase of evidences in pollution in a private water supply; all we want to know is the potentiality, and it will greatly extend our work and usefulness, and also reach a great many more people in the state of Kentucky, if we can use the parcel post in sending out containers. They are very rigid about using iced samples, but that means that perhaps 30 per cent of the people of the state of Kentucky will be deprived of analyses.

In one place where there were 56 cases of typhoid fever out of 120 or more people, the speaker called to his aid the public health service rather than send uniced samples in; but at the same time did send samples by parcel post to our laboratory, and the results were absolutely identical except, of course, the results in gas. But the speaker wishes that some one here that knows a great deal more than he does about it, would contradict Dr. Frost for him, that the state of Kentucky would be justified in receiving samples for analysis without ice.

There is a condition south of the Ohio river that few men north of it can comprehend. There are whole counties without a privy attached to a school house; counties where not one house in ten has a privy of any sort. When they do have them, the privy and wells are found very close together for the sake of convenience, and it is absolutely vital and necessary to the welfare of the state that we bring to the attention of the people the fact that these wells, which apparently yield clear, sparkling water are absolutely unfit sources of water for human consumption. If we send them one of our expensive containers made in the form of an ice box, they will keep them for months at a time because they have no ice, and perhaps not one-fifth of the containers are in active use at a time. They will hold them till winter comes and then there is plenty of ice, and possibly by that time conditions in the water have changed. It is really not a small matter with our department and the speaker would like to know if the men here present think that the chances are that the pollution of water would disappear in these conditions?

The other question he wishes to submit is in regard to the advisability of reclaiming the wash water from a filter plant. One of our water companies wishes to replace the wash water, after sedimentation in a separate tank, into the raw water, and then to get rid of the sludge in the reclamation tank by drainage to low ground. There being no plants of this kind in his state he is without experience in the matter and desires the advice of someone present as to whether to allow it.

DR. EDWARD BARTOW: In a situation such as the gentleman mentions, using some of the containers we would make analyses at the end of six, twelve, twenty-four, thirty-six, forty-eight, or whatever it might be, hours, and determine for ourselves what the results were, and even if we could not conform to the standards, we would make our own standards. We would hesitate, however, to condemn a water which, after storage of four or five days, was shown to contain slight pollution, because of the great possibility of multiplication of bacteria. Care should be taken in the general condemnation of waters of that kind.

With regard to wash water there is a paper submitted by Mr. Babbitt of the University of Illinois (see page 393, vol. 2, JOURNAL AM. W. W. ASSN.), telling about the reclamation of the wash water of the Champaign and Urbana Water Company. That is not exactly parallel to the case which was mentioned. They have been able, however, to save more than 80 per cent of their wash water; allowing it to fall into a sedimentation basin and then pumping the supernatant liquid into the receiving reservoir. By the use of a little alum they are able to remove practically all of the suspended matter, and very little extra burden is placed upon the filters. With a little care, and especially with bacteriological control such an arrangement might be entirely possible in a regular filter.

MR. PAUL HANSEN: The speaker may be able to offer some slight suggestion relative to the difficulties that have been referred to. He happens to have a little familiarity with wells in Kentucky and knows that many of them are badly contaminated.

An analysis of the water is, after all, merely one point of evidence. You may get a good analysis from a well that is subject to contamination at times, so that an analysis may be quite inconclusive. On the other hand, if one knows that a well is near a privy, if one knows that it is subject to the entrance of surface drainage, and if one further knows that a stable yard and possibly a pig pen are not very far off, there is no need of having an analysis. So that before any analyses are made at all there should be obtained a complete description of the source of supply, using perhaps blank forms for this purpose. If it is found that the source is an ordinary open type well, that it is in close proximity to various sources of contamination, one can say offhand that that well is not satisfactory because it is unquestionably in danger of contamination and that an analysis is not worth while until the sources of danger are removed.

While in Kentucky the speaker pursued that policy, and was much more certain of his judgment of the quality of water from wells than he would have been with analyses alone.

Mr. Frederick H. Stover: In reply to second question the speaker wishes to say that in the treatment of clear water he believes it is an advantage to mix the wash water with the water under treatment, because the residual coagulant present in the wash water forms a desirable matrix expediting the formation of a new floc.

Mr. Wilson F. Monfort: Some second hand experience regarding the sending of uniced samples may be of interest. There was a plant in one corner of Missouri sending samples to a state laboratory for examination. The first, the second, the third and the fourth were condemned. The fifth one arrived, was passed upon as good, with the remark, "This is the first sample we have gotten from your city which was iced." All the others had high counts and bad records. It is questionable whether you would not get too bad a result from your uniced samples. If you are limited to sending small packages by parcel post, have you considered putting your portion of media into the sterile bottle and having it incubate on the way for fermentation test only? Is it possible for you to accomplish that and have the incubation under way before the sample reaches you? The speaker is not sure that that could be worked out. You might have trouble; you might have explosions; you might have leakage; but is there not some way of having your package so put up that you might get an enrichment on the way and examine your sample afterward. You might have to use solid media before the method could be gotten into shape. The speaker would be very doubtful about a sample by parcel post which was then submitted to the ordinary examination.

MR. PHILIP BURGESS: The speaker has had some experience similar to those of Mr. Monfort. He was employed by the Ohio State Board of Health for some three years to investigate the water purification plants in Ohio; and, in a number of instances, he made it a special point to send samples into the laboratory and at the same time to make bacterial tests at the plant. The tests showed conclusively that, in the summer time, even when the samples were well iced, results obtained in the laboratory may have little, if any, value, because the total number of bacteria generally increases and because B. coli sometimes increase and sometimes disappear altogether.

Where it is not possible to remain on the ground sufficiently long to complete the presumptive B. coli tests, experience indicates that satisfactory results may be obtained by inoculating the fermentation tubes and shipping the tubes by express to the laboratory, where they are incubated. Apparently similar results are obtained by this method as would be obtained if the incubation commenced when the tubes were first inoculated. Moreover, such a procedure, of course, saves considerable time in the field.

The application of hypochlorite of lime to a water supply also introduces a feature which affects the results of analysis which may be obtained on the ground or on shipped samples. The germicidal action of the hypochlorite of lime continues, and, of course, affects the shipped samples, so that a less bacterial content may be obtained when samples are shipped to and analyzed at the laboratory than would be obtained were the samples plated and incubated immediately after collection. This feature, of course, has an important effect upon the value of analyses obtained from shipped samples.

MR. WM. J. ORCHARD: It might be of interest to the gentlemen present to know that about two months ago in New Jersey, at the suggestion of Dr. Fitz Randolph, in charge of the laboratory of hygiene, there was instituted a system of shipping 250 centimeter bottles out to the various water companies, the supplies of which were obtained from deep wells and the quality of which had been ascertained pretty definitely by quarterly analyses for several years previous. These samples would be sent back to the laboratory at Trenton by parcel post. That was largely brought about in order to economize in the collection of samples, which the law required must be collected by the inspectors of the state boards of health.

The speaker is unable to report the results of this procedure, but in discussing it we decided that in the case of deep well waters, in the twenty-four to thirty-six hours that it would take for the samples to reach the laboratory, the bacteriological changes, if any, would not be of sufficient consequence to influence the interpretation of the analysis, in so far as we knew the quality of the water from several years previous work.

In regard to the other matter that the last gentleman mentioned, it was our practice in New Jersey to inoculate bile tubes in the field when we were testing water supplies, and then ship them to the laboratory or carry them there in order to save time in incubation and in order to get our results sooner than we would had we waited to reach the laboratory before inoculating.

MR. W. W. DE BERARD: Is there not on the market at the present time a sample bottle in which the thermos bottle principle is used? If such a bottle were filled and held for a few hours in the water of which you want a sample, so as to obtain the same temperature, the sample would probably retain that temperature for two or three days without material change.

MR. PAUL HANSEN: The thermos bottle referred to by Mr. De Berard is in the office of Mr. Robert Weston, of Boston.

MR. WILSON F. MONFORT: The one referred to as coming from Kansas is gotten up by Mr. Young and two or three others at Independence, but that, however, requires ice. It is simply a fireless cooker proposition that carries four or more ordinary sized bottles. The one that Mr. Weston uses is a stock thermos bottle, and carries from three to eight two-ounce glass stoppered bottles. The quart size is not large enough to take a number of four-ounce bottles, but would take a single unit for each sample if you are sending the ordinary four-ounce bottles.